GOVERNOR'S OFFICE OF ENERGY DEVELOPMENT

Advancing Utah's Energy Future

Building Batteries - Secondary

Grades 10-12 Chemistry

Strand/Standard CHEM.4.3 Design a device that converts energy from one form into another to solve a problem. Emphasize chemical potential energy as a type of stored energy. (PS3.B, ETS1.A, ETS1.B, ETS1.C)

Lesson Performance Expectations (description): Students will investigate the construction, design and use of batteries to solve energy storage problems.

Materials: Per group:

- 200 ml beaker
- various solutions (salt water, Baking Soda Water, Soda (not cola), weak hydrochloric acid (.1 M)
- strips of metals (https://www.carolina.com/electrochemistry/metal-strips-set-laboratory-grade/874850.pr)
- wires with alligator clips
- Voltmeter
- 1.5 volt motor

Time: 120 minutes

Teacher Background Information:

- "You cannot catch and store electricity, but you can store electrical energy in the chemicals inside a battery." -Antoine Allanore, MIT, Department of Materials Science and Engineering
- The development of improved batteries is essential for the increasing electronic age we live in. Students need a well-developed understanding of batteries, how they work, what the limitations are and what their uses are. This lesson will focus on how batteries work and what kinds work for what uses. Background knowledge of the chemical nature of batteries can be found at: https://engineering.mit.edu/engage/ask-an-engineer/how-does-a-battery-work/

Student Background Knowledge:

- Students need a baseline understanding that substances are made of atoms and molecules and that they interact with one another.
- Students need to understand the basic nature of electricity (moving electrons). They should understand that a circuit carries electricity from one place to another in a connected circle.

Teacher Step by Step:

The following steps are used in the design of the lesson :

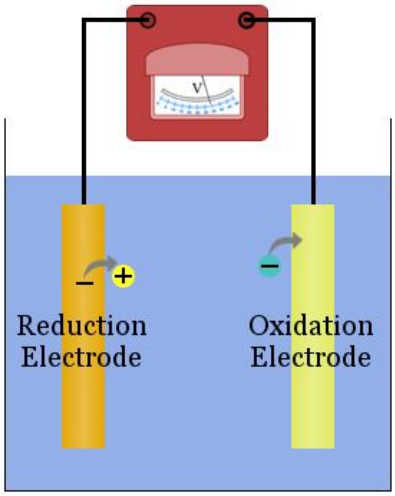
1. **Engage: Introduce *Phenomenon:*** *Ask students to observe the pictured batteries and write their observations on the student sheet.*
2. **Explore:** Ask students to write questions that they have about batteries.
3. **Explain**: Tell students that they will build a battery from the materials you have provided. You can provide as many clues as you would like, but they should have noticed from their observations that batteries have metals, two electronic connections and other substances listed on the outside. You might ask what electricity is and how an electric current is created.

4. **Elaborate**: Students will test the metals and liquids to determine the best combination. To help them summarize what they have learned, they could access these websites or you could share the sites as a class: https://www.explainthatstuff.com/batteries.html or https://engineering.mit.edu/engage/ask-an-engineer/how-does-a-battery-work/
5. **Evaluate:** The students should document their learning on the student sheet in the Claim, Evidence, Reasoning (CER) paragraph and answer the multiple choice questions provided below. A list of battery types is listed after the student sheet.

This is an introductory experience, depending on the background of the students, additional lessons will be necessary.

Assessment of Student Learning.

Diagram of a Battery



1. What does the movement of electrons from electrode to electrode produce?
   a. Electricity*
   b. Waves
   c. New elements
   d. Light

Metal	Voltage
Aluminum-Copper	1.1
Copper-Zinc	1.9
Zinc-Carbon	.7

2. The data above is from an experiment conducted in the classroom which combined different metals in a weak acid solution. The resulting voltage was measured. What should the students conclude?
   a. Copper and Zinc will last the longest in a battery.
   b. Copper and Zinc are the best metals available for batteries.

c. Copper and Zinc are the strongest chemicals available for batteries.
d. Copper and Zinc are the best electron donor and acceptor pair tested.*

3. Which factors influence the battery type people choose for a task? Choose all that apply.
    a. cost*
    b. appearance
    c. lifespan*
    d. size*

4. Why are scientists searching for new ways to store energy in batteries? Choose all that apply.
    a. Batteries are portable.*
    b. Batteries can store energy from alternative sources.*
    c. Batteries can create new sources of clean energy.
    d. Batteries are inexpensive to produce and recycle.

Extension of lesson and Career Connections:
Use the voltmeter to determine which light bulbs can be lit and light the bulb.
https://www6.slac.stanford.edu/news/2019-02-05-untangling-strange-phenomenon-both-helps-and-hurts-lithium-ion-battery-performance

Student Page **Name**_____

Title: Batteries

Phenomenon:

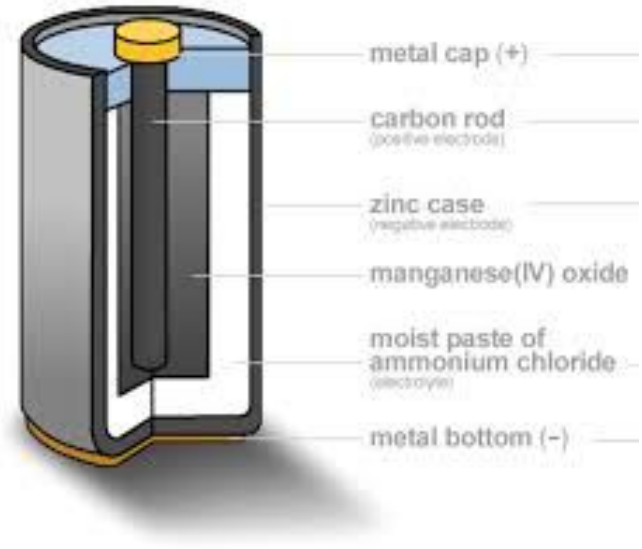
Lithium-ion battery

Lead–acid battery

Nickel–metal hydride battery

Lithium

Alkaline battery



What do you notice?

What questions do you have?

Guiding question: Which substances inside a battery produce the most electricity?

Materials: Metal strips, 2 leads (wires with clips on the end), a beaker, a voltmeter, a light bulb, a variety of liquids (salt water, weak acid (lemon juice), baking soda and water solution)

Procedures:

1.
2.
3.
4.
5.

Drawing of your experimental design:

Data:

Which internet resources did you look up? (use the name of the page)

Model:

Draw your experiment again and describe what you think is happening at the atomic level.

Choose a battery type to research from the list below.

Each student should choose a different type. Make a claim concerning your battery and support it with three evidence statements from your research. Remember that our question was, “Which substances inside a battery produce the most electricity?” Explain your reasoning in the next paragraph. Remember that there are several characteristics that define a good battery.

CER Paragraph:

Claim:

Evidence:

Reasoning:

Review your paragraph based on comments from your group. Rewrite if necessary.

Battery Types:

Primary Cells or Non-Rechargeable	Secondary Cells or Rechargeable

• Alkaline battery (zinc manganese oxide, carbon)
• Aluminium–air battery
• Atomic battery
• Bunsen cell
• Chromic acid cell (Poggendorff cell)
• Clark cell
• Daniell cell
• Dry cell
• Earth battery
• Frog battery
• Galvanic cell
• Grove cell
• Leclanché cell
• Lemon/potato battery
• Lithium battery
• Lithium air battery
• Magnesium battery
• Mercury battery
• Molten salt battery
• Nickel oxyhydroxide battery
  ○ Oxyride battery
• Organic radical battery
• Paper battery
• Pulvermacher's chain
• Silver-oxide battery
• Solid-state battery
• Sugar battery
• Voltaic pile
  ○ Penny battery
  ○ Trough battery
• Water-activated battery
• Weston cell
• Zinc–air battery
• Zinc–carbon battery
• Zinc chloride battery
	• Aluminium-ion battery
	• Carbon Battery
	• Flow battery
	  ○ Vanadium redox battery
	  ○ Zinc–bromine battery
	  ○ Zinc–cerium battery
	• Lead–acid battery
	  ○ Deep cycle battery
	  ○ VRLA battery
	  ○ AGM battery
	  ○ Gel battery
	• Glass battery
	• Lithium-ion battery
	  ○ Lithium ion lithium cobalt oxide battery (ICR)
	  ○ Lithium ion manganese oxide battery (IMR)
	  ○ Lithium ion polymer battery
	  ○ Lithium iron phosphate battery
	  ○ Lithium–sulfur battery
	  ○ Lithium–titanate battery
	  ○ Thin film lithium-ion battery
	  ○ Lithium ceramic battery [5] [6]
	• Magnesium-ion battery
	• Metal–air electrochemical cells
	  ○ Lithium air battery
	  ○ Aluminium–air battery
	  ○ Germanium air battery
	  ○ Calcium air battery
	  ○ Iron air battery
	  ○ Potassium-ion battery
	  ○ Silicon–air battery
	  ○ Zinc–air battery
	  ○ Tin air battery
	  ○ Sodium-air battery
	  ○ Beryllium air battery
	• Molten salt battery
	• Nickel–cadmium battery
	• Nickel hydrogen battery

	● Nickel–iron battery ● Nickel metal hydride battery ○ Low self-discharge NiMH battery ● Nickel–zinc battery ● Organic radical battery ● Polymer-based battery ● Polysulfide bromide battery ● Potassium-ion battery ● Rechargeable alkaline battery ● Rechargeable fuel battery ● Sand battery ● Silicon air battery ● Silver-zinc battery ● Silver calcium battery ● Silver-cadmium battery ● Sodium-ion battery ● Sodium–sulfur battery ● Solid-state battery [7] ● Super iron battery ● UltraBattery ● Zinc ion battery